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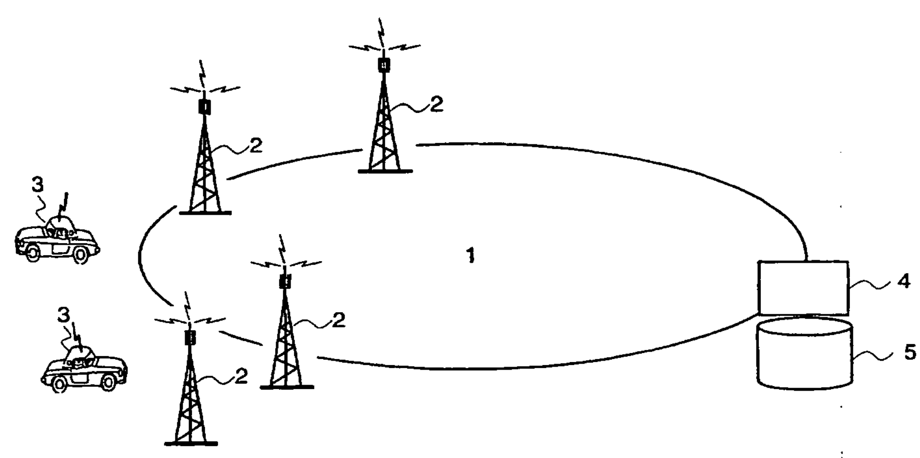
(54) Title: METHOD AND SYSTEM FOR FINDING THE POSITION OF MOBILE TERMINALS



(57) Abstract: System for determining the position of a terminal (3) of a cellular transmission network. The terminal measures the field strengths of adjacent base stations and passes these on to a position-finding server (5). The position-finding server comprises a data base (5) having the positions of a fine-meshed geographic matrix having associated identifier-field-strength combinations measured beforehand in situ. The position-finding server compares the identifier-field-strength combinations transmitted by the terminal with the identifier-field-strength combinations stored in the data base and calculates the position having the best-matching identifier-field-strength combination based thereon. The calculated result may still be verified or corrected based on rough position-finding data received by the terminal from one of the adjacent base stations. The position-finding server may return the calculated result to the terminal and/or to another terminal or to a terminal-monitoring system of, e.g., a fleet owner. The position-finding server may possibly calculate the speed and direction of motion of the terminal from consecutive position calculations.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Method and system for finding the position- of mobile terminals.

BACKGROUND OF THE INVENTION

The invention relates to a method for finding the position- of mobile terminals capable of setting up a link with base stations of a cellularly set up transmission network, a terminal measuring the field strength of its adjacent base stations and recording the combinations of identifier and measured field strength of the nearest base stations according to the field-strength measurements. The invention also relates to a system for carrying out the method.

In known systems, on the basis of the field strengths measured by a terminal of a number (e.g., six) base stations and the (known) positions of said base stations, it is estimated by a central server what the position of the terminal is. The drawback of the known method is that the result is no more accurate than about plus or minus 500 metres. The cause of said inaccuracy is particularly the disturbance of the field-strength image excited by the local base stations as a result of landscape obstacles (forests, hills) and architectural obstacles (flats, electricity masts, factories, offices), as a result of which the field-strength image deviates far from the theoretical ("ideal") field-strength image.

SUMMARY OF THE INVENTION

The invention proposes a method and system with which it is possible to achieve a considerably more accurate result, namely, location finding with an accuracy of approximately plus or minus 5 metres.

The method according to the invention provides for the terminal passing on the recorded identifier-field-strength combinations to a location-finding server, comprising a data base having stored therein the positions of a fine-meshed geographic matrix - having meshes of, e.g., 5x5 metres - with associated identifier-field-strength combinations measured in situ in advance, in which location-finding server the identifier-field-strength combinations transmitted by the terminal are compared to the identifier-field-strength combinations stored in the data base and the position having the best-matching identifier-field-strength combination is determined. The system according to the invention, suitable for implementing the above method, comprises the position-finding server and data base having the identifier-field-strength combinations measured in situ as already referred to, in which the identifier-field-strength

combinations transmitted by the terminal are matched with those stored in the data base.

As referred to in the foregoing, the terminal is capable of receiving, from at least one of the adjacent base stations, rough position-finding data (having an accuracy of about 500 metres). Said rough data may be passed on, if so desired, by the terminal to the position-finding server and be used by the position-finding server for verifying the outcome of the matching process. Due to this, the result will even gain in reliability. The position of the terminal, determined and possibly verified by the position-finding server, may be returned to the mobile terminal whose position was determined, but said position, calculated by the position-finding server, may also be transmitted to another terminal or system, e.g., a monitoring system for mobile terminals of a transportation company.

The method and the system according to the invention in practice may be implemented without exorbitant investments if, as a data base for the position-finding server, there is utilised a data base, usually already present in a cellular wireless transmission system, which primarily serves for planning and managing the geographic position, field strength etc. of the base-station system of the cellular transmission network.

The results of the position finding by the position-finding server may still be improved if, in the calculation of the terminal position, preceding position findings are taken into account, e.g., by calculating the speed and direction of motion and extrapolating said data.

EXEMPLARY EMBODIMENTS

FIG. 1 schematically shows an exemplary embodiment of a system for finding the position of the mobile terminals 3, which are capable of setting up a link with base stations 2 of a cellularly set up transmission network 1. A terminal 3 comprises means (not shown) for measuring the field strength of its adjacent base stations 3 and for recording the combinations of identifier and measured field strength of the nearest base stations, according to the field-strength measurements. To the network 1, there is connected a position-finding server 4, to which the terminal 3 passes on the recorded identifier-field-strength combinations. The position-finding server 4 comprises a data base 5 having stored therein the positions of a fine-meshed geographic matrix having associated identifier-field-strength combinations measured in advance in situ. The position-

finding server 4 compares the identifier-field-strength combinations transmitted by the server with the identifier-field-strength combinations stored in data base 5 and determines the position with the best-matching identifier-field-strength combination.

In order to clarify all this, FIG. 2 shows a geographic map of the area in which the terminal 3 is located at a specific point in time. Terminal 3 sets up a link with the network 1 shown in FIG. 1 and the position-finding server 4 by way of the base station 2. Terminal 3 measures the field strength of the nearest base stations 3, in FIG. 2 - based on the relatively high field strength - the base stations denoted by G, I and J. Terminal 3 records the combinations of identifier (in this case "G", "I" and "J") and measured field strength for each of said base stations. Suppose that the terminal records the following combinations: "G36 I31 J69", in which the letters denote the station identifier and the numbers against them denote the field strength measured by the terminal.

To the network 1 shown in FIG. 1, there is connected a position-finding server 4, to which the terminal 3, by way of a base station 2 (G, I or J) passes on the recorded identifier-field-strength combinations. The position-finding server 4 comprises a data base 5 having stored therein the positions of a fine-meshed geographic matrix having associated identifier-field-strength combinations measured in advance in situ. Part of the contents of data base 5 looks, e.g., as follows. From left to right, one sees, of the boxed area in FIG. 3, the identifier-field-strength combinations measured in the various areas (in situ): "p05 G15 I05 J70", e.g., indicates that area p05 was the measured field strength of base station G, 25 was the field-strength unit, the field strength of station I was 5 units and the field strength of station J was 70 units. Only the field strengths greater than zero are noted, and therefore not, e.g., the field strengths of the base stations A, B, C etc., which are too negligibly small in said areas.

-	-	-	-
p03	-	-	-
p04	-	-	-
p05	G15	I05	J70
p06	G25	I10	J75
p07	G40	I20	J70
p08	G50	I30	J60
p09	G60	I40	J50

p10	G60	I50	J40
p11	G50	I70	J30
p12	-	-	-
p13	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
q03	-	-	-
q04	-	-	-
q05	G20	I05	J80
q06	G25	I10	J90
q07	G30	I20	J80
q08	G35	I30	J70
q09	G40	I40	J50
q10	G35	I50	J40
q11	G30	I60	J30
q12	-	-	-
q13	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
r03	-	-	-
r04	-	-	-
r05	G10	I05	J95
r06	G20	I10	J99
r07	G25	I20	J90
r08	G30	I35	J75
r09	G35	I50	J60
r10	G30	I70	J40
r11	G25	I80	J30
r12	-	-	-
r13	-	-	-
-	-	-	-
-	-	-	-

It should still be noted that, in FIG. 3, the "iso-field-strength lines" (for simplicity's sake) are drawn circularly. Such would only be the case, however, if there were no obstacles in the vicinity of the base stations 2, such as (schematically shown in the figures 2, 3

and 4) forests, buildings, hills etc. Such obstacles cause field-strength disturbances, as a result of which the field-strength course in practice is significantly more erratic (non-circular "iso-field-strength lines"). A great advantage of the invention is that, however erratic the field-strength course is, it is always stored in the data base 5; after all, the data base 5 is a reflection of the real, non-ideal local field-strength image measured in situ. In fact, this is the reason why the system according to the invention provides such a great accuracy in position finding. Of course, it is a condition that in the data base 5 the ID-field-strength combinations stored therein be kept up to date by, in the event of any change in the local terrain which may affect the field-strength image, having the manager of the system carry out new field-strength measurements in situ and having the measurement results entered into the data base.

The position-finding server 4 compares the identifier-field-strength combinations transmitted by the terminal, "G36 I31 J69", with the identifier-field-strength combinations stored in the data base 5 - see example - and determines - by way of a matching algorithm - the position having the best-matching identifier-field-strength combination "best match". In the above example, this is "q08 G35 I30 J70", which signifies that terminal 3, based on the field strengths measured by the terminal on the one hand, and on the other hand the previously measured field strengths stored in the data base 5, would be located within the area that is denoted by the co-ordinates q08. FIG. 4 demonstrates that the terminal is indeed located within area q08.

As the data base 5, there is preferably used a system data base which is already in use and is kept up to date for planning and managing the geographic position, field strength etc. of the base-station system of the cellular transmission network. Inter alia it is calculated, using said data base, where new base stations must be placed. In the event of modifications in local situations, e.g., in the event of the construction of architectural works which may affect the effective range of base stations (more attenuation), there are carried out new measurements at such locations and the data base is updated based on the results thereof. When in specific areas the field strength of the adjacent base stations is too low (this is often pointed out by terminal users and passed on to the network manager), as a rule there will be added a new base station. Subsequently, in this area field-strength measurements are carried

out once again and the results thereof are entered into the data base 5.

It may be that, in looking through the data base, there is not found one, but two or more good matches, as a result of which it is unclear at which position the terminal is located.

In order to increase the score even more, use is preferably made of the option that the terminal receives rough position-finding data from the nearest base station, the base station having the greatest field strength (in our example, station J having a field strength of 69) - by way of which the link to the network runs at that point in time. Said position-finding data indicates the estimated distance to the base station J with an accuracy of about 500 metres. Apart from the identification-field-strength combinations, the terminal now also passes on the rough distance indication from station J to the position-finding server 4.

Position-finding server 4 now verifies whether the co-ordinates of the "best-match" location correspond to the rough indication with respect to base station J.

The position of the terminal determined and possibly verified by the positions-finding server may be returned to the mobile terminal whose position has been determined. It is also possible, however, that the terminal position determined by the position-finding server is passed on to another - mobile or nonmobile - terminal or to a terminal-monitoring system with which, e.g., a fleet owner may monitor where his lorries are located.

The calculation algorithm of the position-finding server may still be refined by, in the calculation of the terminal position, involving preceding position determinations. Thus, the position-finding server 4 may calculate, from consecutive position calculations, the speed and direction of motion of the terminal and extrapolate said data in the calculation of the new terminal position. Based on said new estimated terminal position, the "best-match" result may then once again be verified or corrected.

CLAIMS

1. Method for determining the position of mobile terminals (3) which may set up a link with base stations (2) of a cellularly set up transmission network (1), a terminal measuring the field strength of its adjacent base stations and recording the combinations of identifier and measured field strength of the nearest base stations, according to the field-strength measurements, CHARACTERISED IN THAT the terminal passes on the recorded identifier-field-strength combinations to a position-finding server (4), comprising a data base (5) having stored therein the positions of a fine-meshed geographic matrix having associated identifier-field-strength combinations measured beforehand in situ, in which position-finding server the identifier-field-strength combinations transmitted by the terminal are compared with the identifier-field-strength combinations stored in the data base and the position having the best-matching identifier-field-strength combination is determined.

2. System for determining the position of mobile terminals which are capable of setting up a link with base stations of a cellularly set up transmission network, with a terminal comprising means for measuring the field strength of its adjacent base stations and for recording the combinations of identifier and measured field strength of the nearest base stations, according to the field-strength measurements, CHARACTERISED BY a position-finding server to which the terminal passes on the recorded identifier-field-strength combinations, which position-finding server comprises a data base having stored therein the positions of a fine-meshed geographic matrix having associated identifier-field-strength combinations measured beforehand in situ, which position-finding server compares the identifier-field-strength combinations transmitted by the terminal with the identifier-field-strength combinations stored in the data base and determines the position having the best-matching identifier-field-strength combination.

3. System according to claim 2, the terminal also receiving rough position-finding data from at least one of the adjacent base stations, CHARACTERISED IN THAT the terminal also passes on the rough position-finding data to the position-finding server and that the position-finding server verifies the position determined by said

comparison of identifier-field-strength combinations, based on said rough position-finding data.

4. System according to claim 2 or 3, CHARACTERISED IN THAT the position of the terminal, determined and possibly verified by the position-finding server, is transmitted on to the mobile terminal whose position has been determined.

5. System according to claim 2, 3 or 4, CHARACTERISED IN THAT the position of the terminal, determined and possibly verified by the position-finding server, is transmitted on to another, mobile or nonmobile, terminal.

6. System according to claim 2, 3, 4 or 5, CHARACTERISED IN THAT the position of the terminal, determined and possibly verified by the position-finding server, is transmitted on to a terminal-monitoring system.

7. System according to claim 2, CHARACTERISED IN THAT said data base is a data base for planning and managing the geographic position, field strength etc. of the base-station system of the cellular transmission network.

8. System according to claim 2, CHARACTERISED IN THAT the position-finding server involves preceding position determinations in the calculation of the terminal position.

9. System according to claim 8, CHARACTERISED IN THAT the position-finding server calculates the speed and direction of motion of the terminal from consecutive position calculations and extrapolates said data in the calculation of a new terminal position.

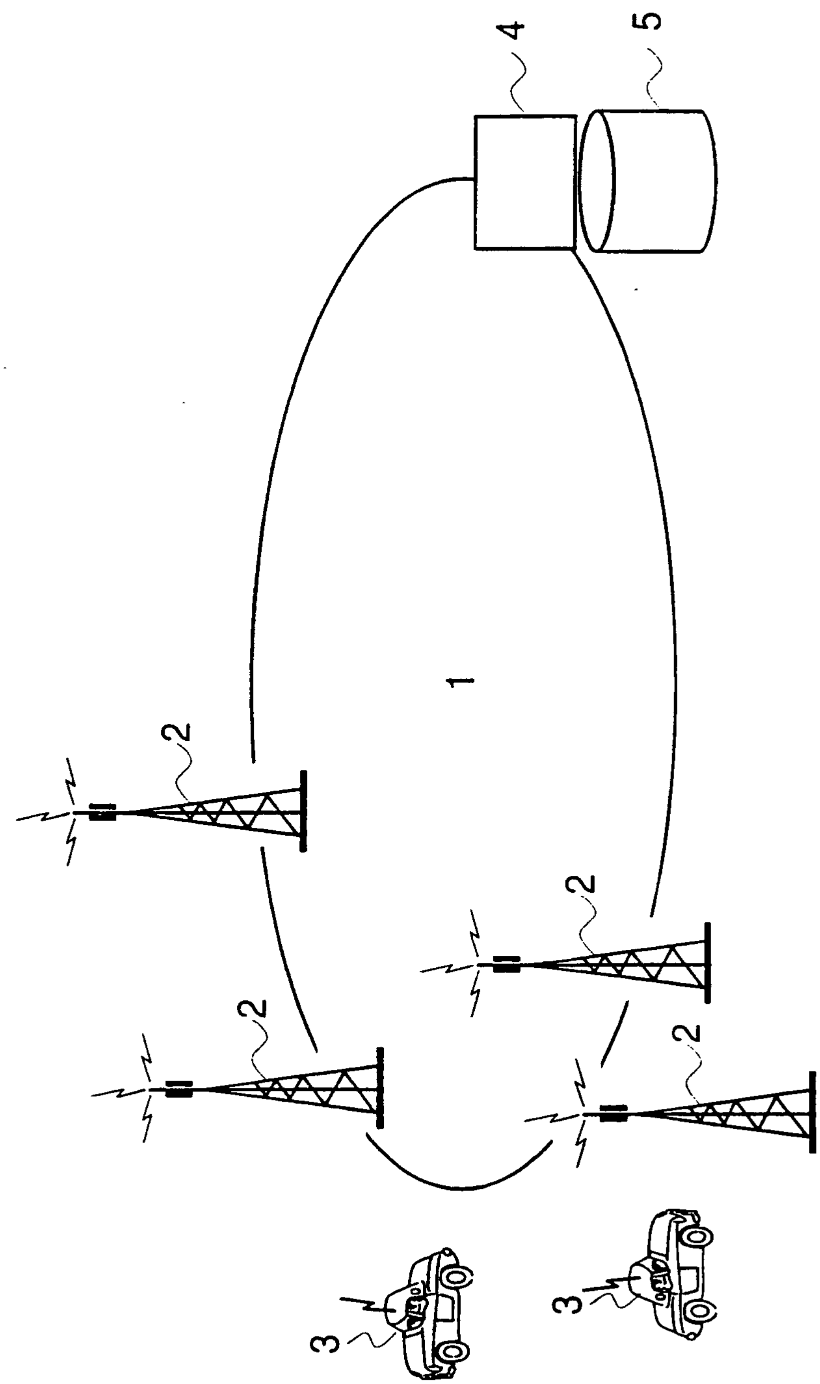

FIG. 1

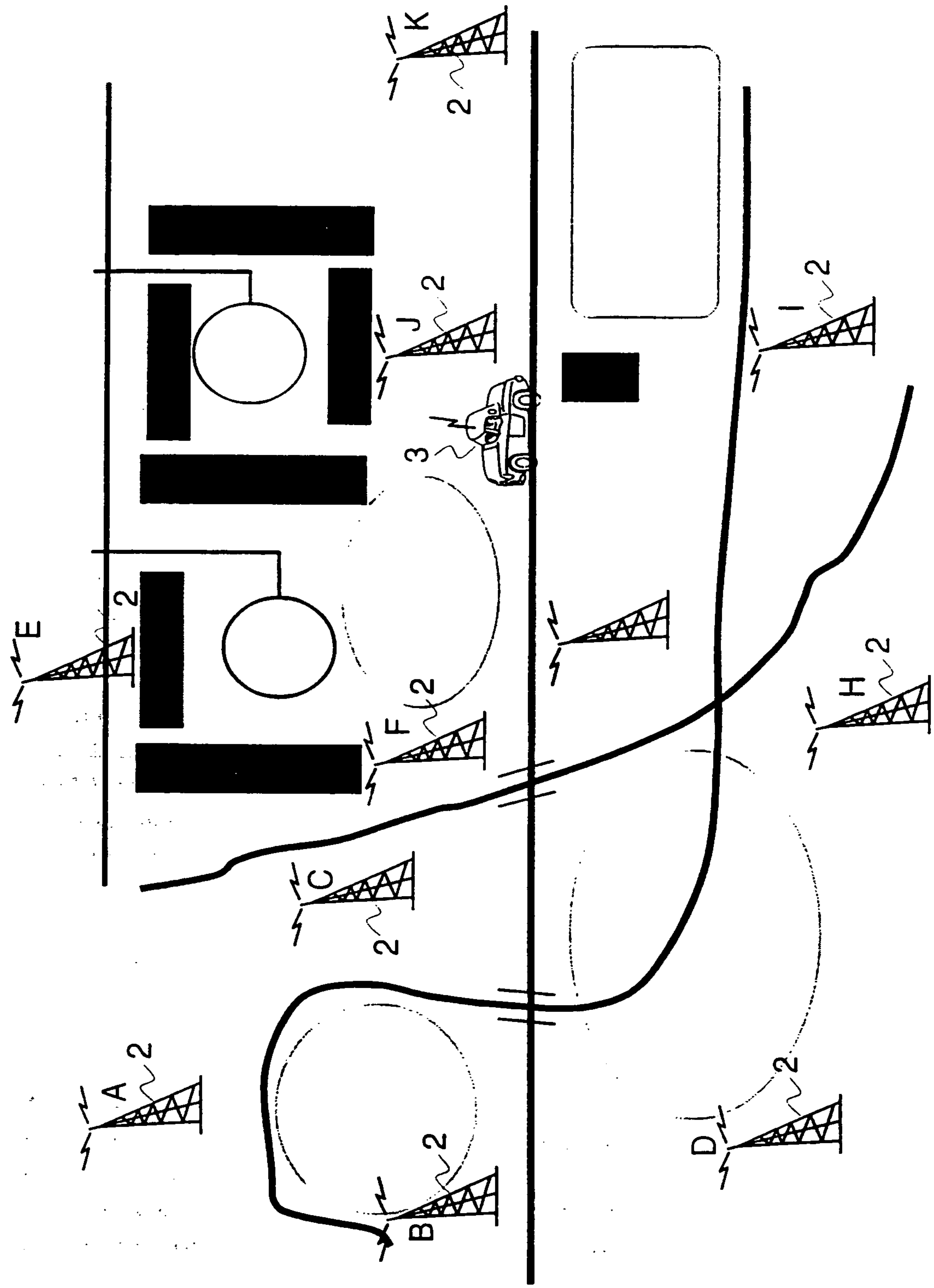

FIG. 2

3/4

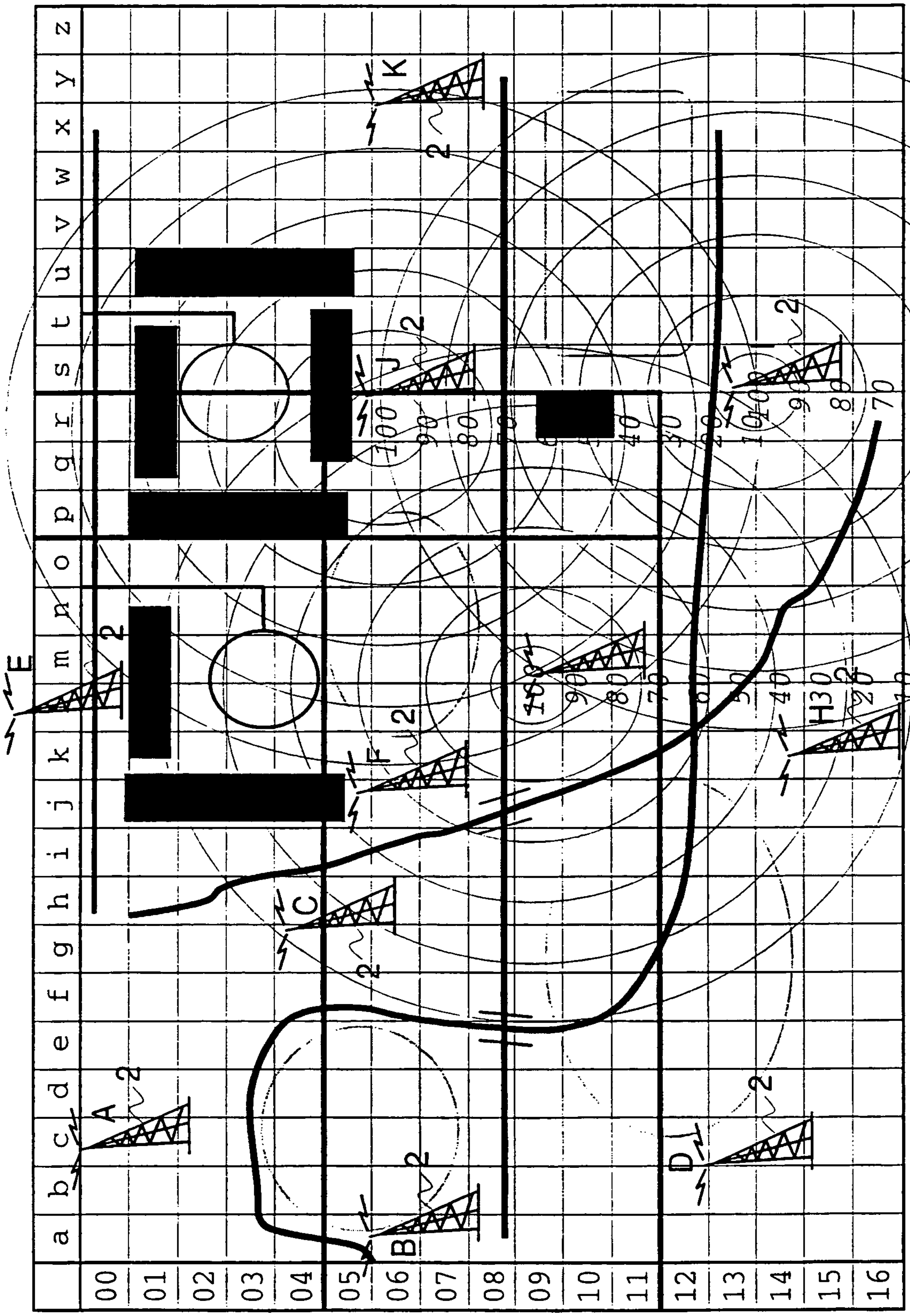
a b c d e f g h i j k l m n o p q r s t u v w x y z
00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16
A
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FIG. 3

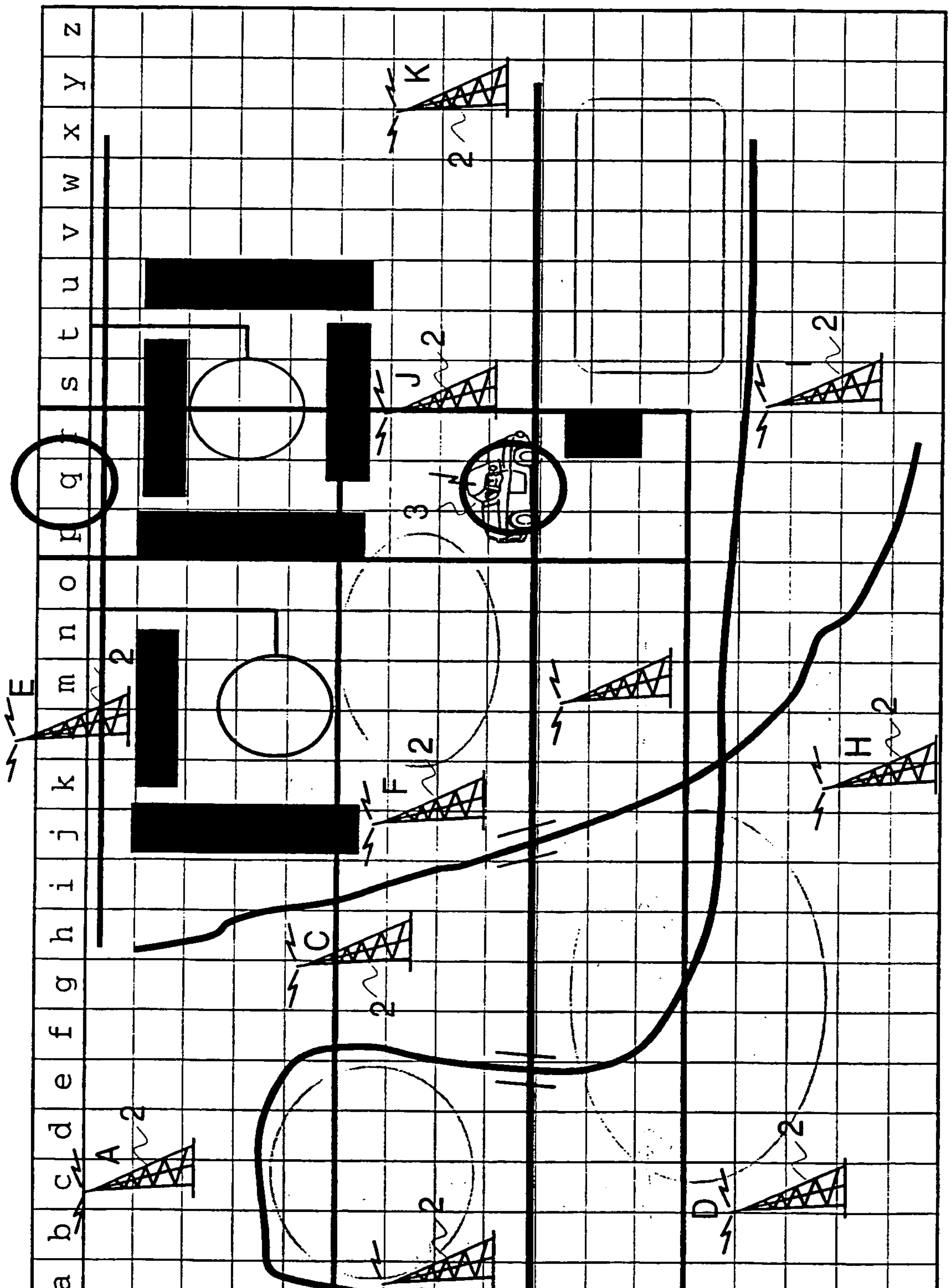

FIG. 4

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 00/08887

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04Q7/38

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04Q G01S

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

INSPEC, EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 98 15149 A (NOKIA TELECOMMUNICATIONS OY ;LEPPAENEN RISTO (FI); LAIHO STEFFENS) 9 April 1998 (1998-04-09) page 2, line 18 -page 3, line 27 page 5, line 27 -page 6, line 36 page 8, line 2 -page 9, line 6 ---	1-9
X	EP 0 868 101 A (DEUTSCHE TELEKOM MOBIL) 30 September 1998 (1998-09-30) the whole document ---	1,2,7
A	EP 0 631 453 A (TELIA AB) 28 December 1994 (1994-12-28) the whole document ---	1,2,5,6, 8,9

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search	Date of mailing of the international search report
21 March 2001	27/03/2001

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 00/08887

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JUNIUS M ET AL: "NEW METHODS FOR PROCESSING GSM RADIO MEASUREMENT DATA: APPLICATIONSFOR LOCATING, HANDOVER, AND NETWORK MANAGEMENT" PROCEEDINGS OF THE VEHICULAR TECHNOLOGY CONFERENCE,US,NEW YORK, IEEE, vol. CONF. 44, 1994, pages 338-342, XP000496691 the whole document	1-3,6

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/EP 00/08887

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